

Integrating Nanoscale Science and Engineering into the Undergraduate Engineering Curriculum

**Prof. Wendy Crone, Dr. Ken Lux, Prof. Robert Carpick,
Engineering Physics**

**Prof. Don Stone, Prof. Eric Hellstrom,
Materials Science and Engineering**

University of Wisconsin - Madison



**Materials Research Science and Engineering Center
on Nanostructured Materials and Interfaces**
Interdisciplinary Education Group



UW-Madison NUE Activity

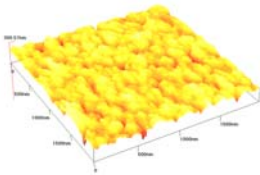
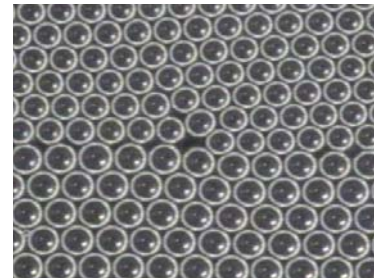
- Our work integrates nanoscale science and engineering educational modules into key introductory and advanced undergraduate courses in the College of Engineering at the University of Wisconsin – Madison.
- The six courses targeted for modification range from freshman introductory courses to advanced level materials and mechanics courses.
- Most of the modifications focus on removing outdated content and replacing it with new cutting-edge content based on current research and emerging applications in nanotechnology.

Introduction to Engineering (EPD 160)



Introduction to Modern Materials (MSE 250)

Materials Laboratory II & III (MSE 361 & 362)

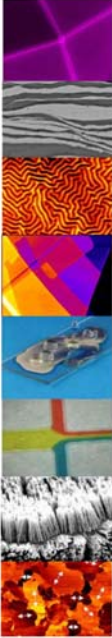


Advanced Mechanical Testing of Materials (EMA 611)

Micro- and Nanoscale Mechanics (EMA 601)



A Course in Micro- and Nanoscale Mechanics



Spring 2003
Micro- and Nanoscale Mechanics
Instructors: W.C. Crone and R.W. Carpick
Tue./Thurs. 11:00-12:15p
EMA 601 (Lecture 3)
Class #51123
3 credits

Course Description:

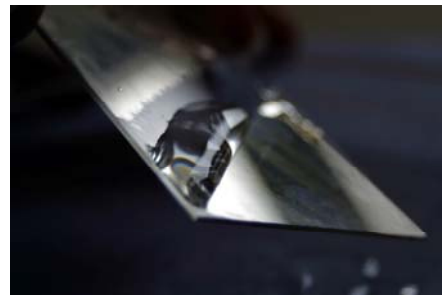
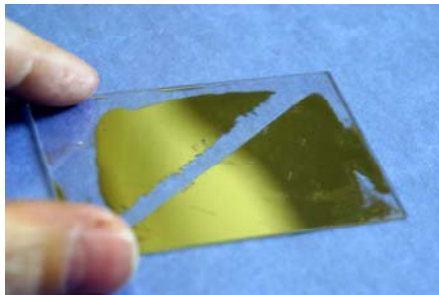
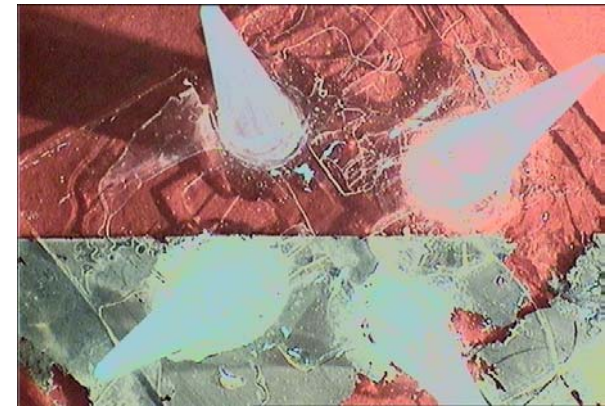
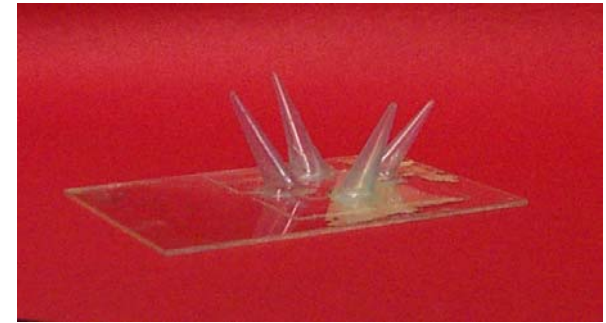
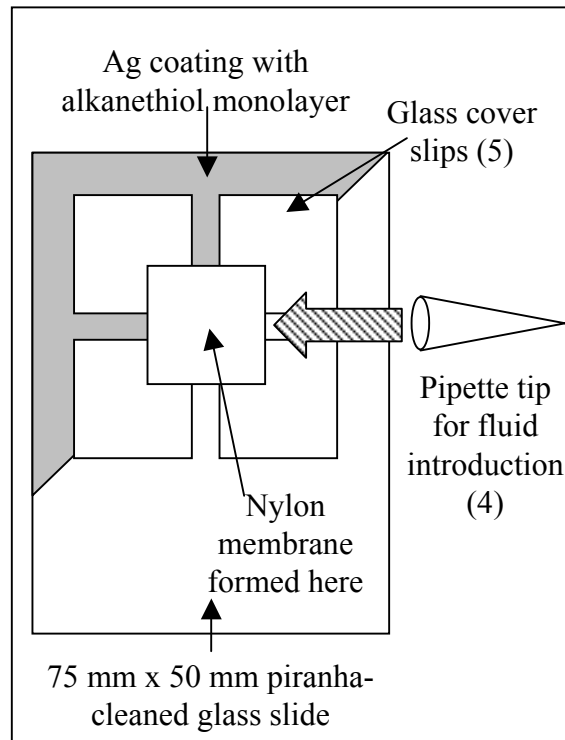
This course will provide an introduction to nanoscale engineering with a direct focus on the critical role that mechanics needs to play in this developing area. Engineering is progressing to ever-smaller scales, enabling new technologies, materials, devices, and applications. Mechanics enters a new regime where the role of surfaces, interfaces, defects, material property variations, and quantum effects play more dominant roles. We will discuss how mechanics becomes integrated with the fields of materials science, chemistry, physics, and biology at this scale. We will cover a variety of concepts and applications, drawing connections to both established and new mechanics approaches. We will discuss the limits of continuum mechanics and present newly developed mechanics theories and experiments tailored to describe micro- and nano-scale phenomena. We will emphasize specific applications throughout the course.

Prerequisites:

Students should have a general understanding of mechanics and materials, and a deep curiosity in extending their knowledge beyond traditional bounds. This course is open to graduate students and advanced undergraduates, but it is designed for students willing and able to work at least at the level of a first year graduate student. Literature reviews, critical peer discussion, and student presentations will be an integral part of the course.

Course Web Page:

<http://www.engr.wisc.edu/ep/ema/courses/ema601micronano.html>

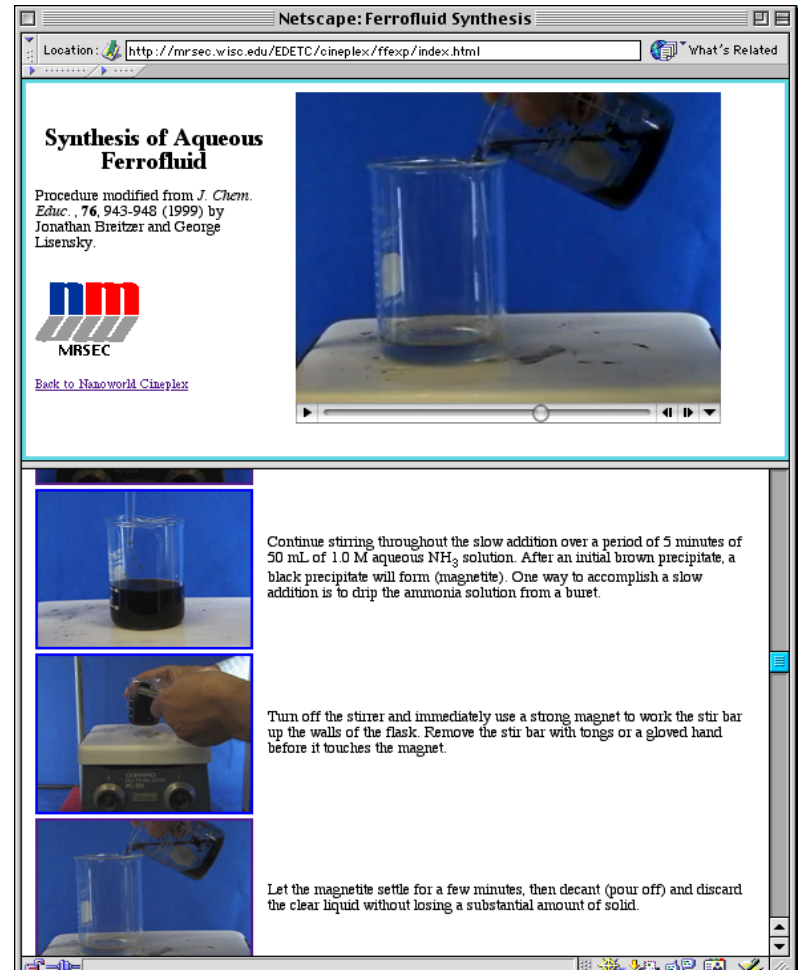


Web-Based Education Tools

Nanotechnology Lab Manual



Nanoworld Cineplex Demonstrations
<http://www.mrsec.wisc.edu/nano>



nm Education and Outreach
MRSEC

Click on an image to view the movies.
Movies require QuickTime, and the QuickTime Plug-In for your internet browser. Windows users of Internet Explorer 6.0 will need the ActiveX control.

Get QuickTime

These movies average 2 MB each in size and are not recommended for modem users.

Lab Manual for Nanoscale Science and Technology

 This project supported by a National Science Foundation Distinguished Teaching Scholar Award.

Synthesis of aqueous ferrofluid nanoparticles
A solution of nanoparticles formed by mixing Fe(II), Fe(III) and a surfactant form a magnetic "liquid."
[More information on ferrofluids](#) [Ferrofluid Movies](#)

Decanethiol monolayer on silver
Coating silver with a monolayer of decanethiol produces a non-polar surface on which water beads up.

Organic Light Emitting Diodes
An inorganic complex between a transparent tin oxide electrode and an active metal electrode produces light when an external voltage is supplied.
[More information on OLEDs](#)

Synthesis of Colloidal Gold
Nanoparticles of gold are red in color. The presence of a colloid can be detected by the reflection of a laser beam from the particles.

Critical Micelle Formation
Above a certain concentration, called the critical micelle concentration (CMC), surfactant molecules spontaneously form micelles. When the CMC is reached, a water-insoluble hydrophobic dye dissolves within the micelles.

Titanium Dioxide Raspberry Solar Cell
Using a dye found in raspberries to absorb sunlight, a tin oxide electrode, a graphite electrode, and nanocrystalline titanium dioxide, makes a solar cell that will produce a voltage.
[JCE Solar Kit](#)

Synthesis of CdSe Nanoparticles
The visible absorption of CdSe nanoparticles depends on the size of the particle. Immediately after the reactants in hot solution are combined, samples are withdrawn and quenched at room temperature to produce a series of increasing particle sizes.

Disassembly of a Liquid Crystal Watch
This experiment deals with the disassembly of an inexpensive liquid crystal display (LCD) watch and testing several of the properties of the LCD panel.
[More information on liquid crystal watches](#)

Also see our [Nanoworld Cineplex of Movies](#).

Benefits of a Video-based Lab Manual

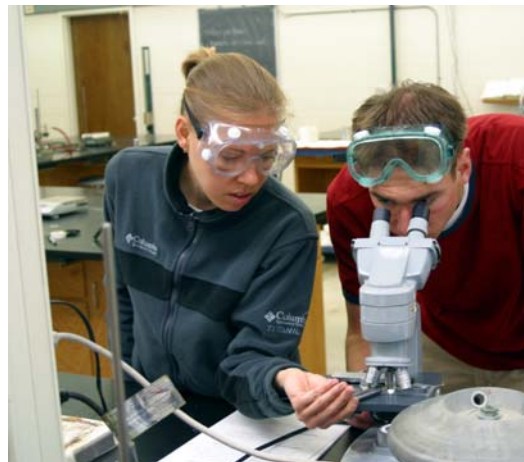
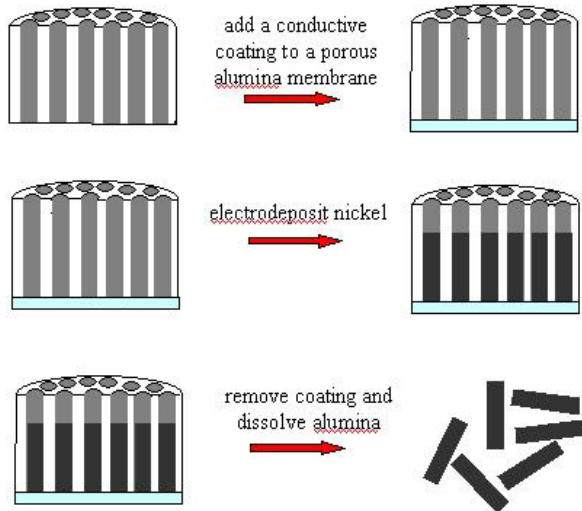
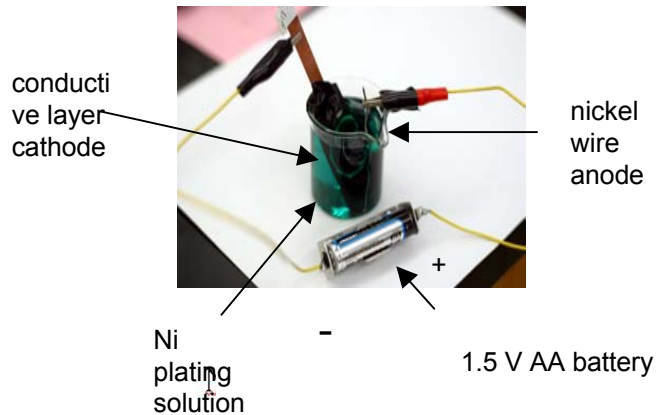
Can be utilized as:

- Video replacement for traditional lab manual
- Lab access for disabled students
- “Stand-alone” demo
- Can avoid the use of toxic materials

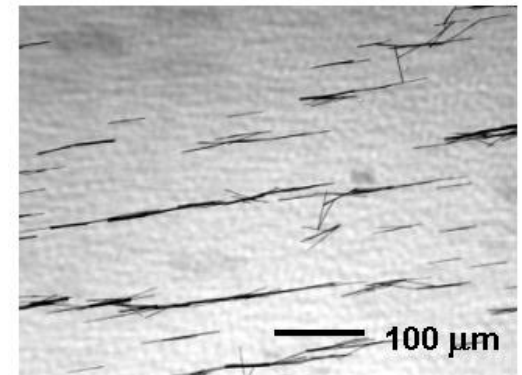
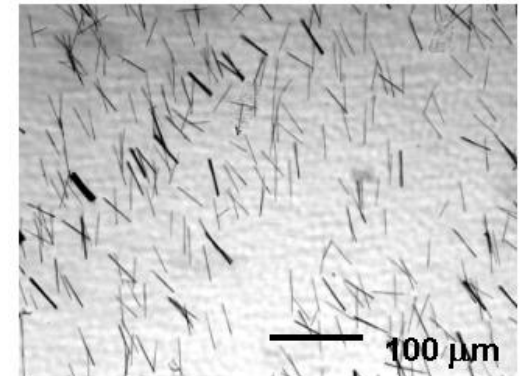
Laboratory Development Process

- Topics chosen from research-based nanotechnology concepts
- Identification of target audience
- Reliability
 - Modify procedures for consistent results
- Modifications
 - Address needs and limitations of classroom environment (e.g. time, cost, equipment, safety)
- Assess and Update

Nickel Nanowire Synthesis



optical microscope
20X magnification



Nickel Nanowire Lab Assessment

Milwaukee School of Engineering (MSOE)	Chemistry 200 (a second quarter general chemistry course for engineering students)	3 of 12 pairs made nanowires successfully
UW-Madison	MS&E 361 (a sophomore level materials laboratory)	5 of 9 pairs
UW-Madison	Chemistry 311 (an intermediate inorganic chemistry course)	23 of 24 pairs

“Nano stuff isn’t as ‘mystical’ as it seems.”

-- *MSE 361 student*

“I liked the fact that this lab had a direct correlation to current research.”

-- *Chem 311 student*

“I found out that basic chemistry can be used to make something so small.”

-- *Chem 311 student*

Impact

- Approximately 400 engineering students will be impacted in the first year of implementation on the UW-Madison campus.
- The educational tools developed will be disseminated through a variety of mechanisms including
 - *Laboratory Manual for Nanoscale Science and Technology*
<http://www.mrsec.wisc.edu/edetc/nanolab/index.html>
 - Nanoworld Cineplex
<http://www.mrsec.wisc.edu/edetc/cineplex/index.html>

Acknowledgements

- National Science Foundation
 - Nanotechnology Undergraduate Education grant (award # EEC-0304479) jointly funded by the Division of Civil and Mechanical Systems (CMS) and the Division of Chemical and Transport Systems (CTS) in the Directorate for Engineering (ENG) and the Division of Materials Research (DMR) in the Directorate for Mathematical and Physical Sciences (MPS)
 - Materials Research Science and Engineering Center (MRSEC) on Nanostructured Materials and Interfaces (award # DMR-0079983)
 - CAREER Awards to Wendy Crone (award # CMS-0134385) and Robert Carpick (award # CMS-0134571)
 - Graduate Research Fellowship to Anne Bentley